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Woodruff Narrows Reservoir Uinta County, Wyoming

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Cheyenne

Aug 77

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

WOODRUFF NARROWS RESERVOIR

UINTA COUNTY

WYOMING

EPA REGION VIII

WORKING PAPER No. 893

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Wyoming Department of Environmental Quality for professional involvement, to the Wyoming National Guard for conducting the tributary sampling phase of the Survey, and to those Wyoming wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

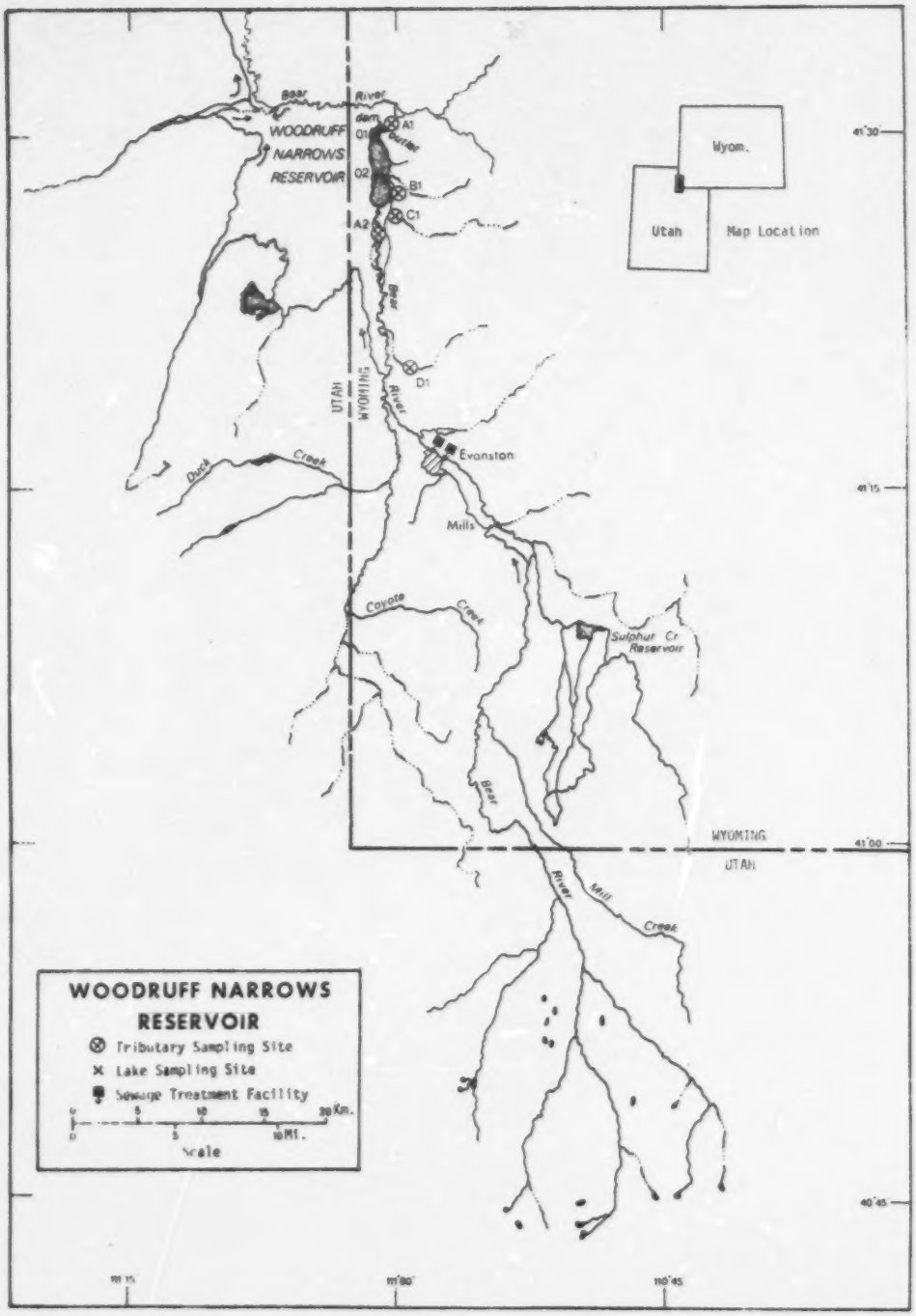
Brigadier General James L. Spence, The Adjutant General of Wyoming, and Project Officer Colonel Donald L. Boyer, who directed the volunteer efforts of the Wyoming National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Wyoming

NAME	COUNTY
Big Sandy	Sublette, Sweetwater
Boulder	Sublette
Boysen	Fremont
De Smet	Johnson
Flaming Gorge	Sweetwater, WY; Daggett, UT
Fremont	Sublette
Glendo	Converse, Platte
Keyhole	Crook
Ocean	Fremont
Seminoe	Carbon
Soda	Sublette
Viva Naughton	Lincoln
Woodruff Narrows	Uinta
Yellowtail	Bighorn, WY; Bighorn, Carbon, MT


Bear River
dam
WOODRUFF NARROWS RESERVOIR
A1
O1
Outlet
O2
B1
C1
A2
Bear
UTAH
WYOMING
River
D1
Evanston
Duck Creek
Mills
Coyote Creek
Sulphur Cr Reservoir
Bear River
Mill Creek
WYOMING
UTAH
Wyom.
Utah
Map Location
41°30
41°15
41°00
40°45
111°15
111°00
110°45
WOODRUFF NARROWS RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 5 10 15 20 Km.
0 5 10 Mi.
Scale

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO. PB277047
4. TITLE AND SUBTITLE Report on Woodruff Narrows Reservoir, Unita County, Wyoming		5. REPORT DATE Prepared August 1977 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 893
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
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15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		48G

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release unlimited		39
	20. SECURITY CLASS (This page)	22. PRICE
		A03-A01

EPA Form 2220-1 (9-73)

WOODRUFF NARROWS RESERVOIR

STORET NO. 5613

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Woodruff Narrows Reservoir is eutrophic. It ranked last in overall trophic quality when the 14 Wyoming lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. Twelve of the water bodies had less median total phosphorus, 11 had less median dissolved ortnophosphorus, seven had less median inorganic nitrogen, 12 had less mean chlorophyll a, and 11 had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at station 1 in August.

B. Rate-Limiting Nutrient:

Because of significant nutrient changes in the samples during shipment from the field to the laboratory, the algal assay results are not considered representative of conditions in the reservoir at the times the samples were collected (09/18/75 and 10/16/75).

The reservoir data indicate nitrogen limitation all four sampling times.

C. Nutrient Controllability:

1. Point sources--The City of Evanston was the only known point source contributing phosphorus to the reservoir during the sampling year and added 15.7% of the total phosphorus load.

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* See Appendix A.

The present phosphorus loading of 6.02 $g/m^2/yr$ is more than five times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic load (see page 12). Because of this, the phosphorus inputs of all sources, point and non-point, would have to be minimized to the greatest possible extent to result in a significant improvement in the trophic condition of the reservoir.

1. Non-point sources--Non-point sources, including direct precipitation, contributed 84.3% of the total phosphorus load to the reservoir during the sampling year. The Bear River added 80.8% of the total, and the ungaged tributaries contributed an estimated 3.2%.

The phosphorus export rate of the Bear River was 18 $kg/km^2/yr$ (see page 11). This rate is considerably higher than the rate of Hams Fork, the major tributary of nearby Viva Naughton Reservoir* (7 $kg/km^2/yr$).

* Working Paper No. 892

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 7.08 kilometers^2.
2. Mean depth: 4.9 meters.
3. Maximum depth: 168.9 meters.
4. Volume: 34.692 x 10^6 m^3.
5. Mean hydraulic retention time: 58 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Bear River	1947.7	7.060
Minor tributaries & immediate drainage -	75.8	0.009
Totals	2023.5	7.069

2. Outlet -

Bear River	2030.6**	6.870**

C. Precipitation***:

1. Year of sampling: 19.25 centimeters.
2. Mean annual: 23.5 centimeters.

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† Table of metric equivalents--Appendix B.
†† Prior, 1974.
* For limits of accuracy, see Working Paper No. 175, "... Survey Methods, 1973-1976".
** Includes area of reservoir; lesser outflow due to evaporation.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Woodruff Narrows Reservoir was sampled four times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last two visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 9.4 meters at station 1 and 7.3 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR WOODRUFF NARROWS RESERVO
STORET CODE 5613

PARAMETER	1ST SAMPLING (5/16/75) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 7/75) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/18/75) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	7.1 - 10.7	9.3	9.2	16.8 - 20.2	19.5	19.7	12.3 - 13.4	12.8	12.8
DISS OXY (MG/L)	8.0 - 9.2	8.7	8.8	1.8 - 6.8	5.8	6.2	8.2 - 9.8	8.8	8.6
CNDCTVY (MCROMO)	331. - 362.	347.	344.	197. - 217.	211.	212.	240. - 252.	246.	244.
PH (STAND UNITS)	8.5 - 8.6	8.5	8.5	8.3 - 8.8	8.7	8.7	8.0 - 9.0	8.8	8.9
TOT ALK (MG/L)	264. - 306.	285.	283.	112. - 116.	114.	114.	134. - 142.	138.	139.
TOT P (MG/L)	0.063 - 0.098	0.073	0.068	0.038 - 0.166	0.061	0.049	0.071 - 0.092	0.081	0.083
ORTHO P (MG/L)	0.007 - 0.024	0.015	0.016	0.015 - 0.086	0.030	0.025	0.007 - 0.011	0.008	0.007
NO2+NO3 (MG/L)	0.020 - 0.070	0.026	0.020	0.020 - 0.060	0.026	0.020	0.020 - 0.020	0.020	0.020
AMMONIA (MG/L)	0.020 - 0.030	0.024	0.020	0.060 - 0.320	0.179	0.175	0.020 - 0.020	0.020	0.020
KJEL N (MG/L)	0.400 - 0.700	0.562	0.600	0.300 - 0.700	0.437	0.300	0.400 - 0.700	0.550	0.550
INORG N (MG/L)	0.040 - 0.100	0.050	0.040	0.090 - 0.340	0.205	0.195	0.040 - 0.040	0.040	0.040
TOTAL N (MG/L)	0.420 - 0.770	0.589	0.620	0.320 - 0.720	0.464	0.340	0.420 - 0.720	0.570	0.570
CHLRPYL A (UG/L)	6.1 - 6.1	6.1	6.1	2.5 - 4.0	3.3	3.3	26.7 - 35.6	31.1	31.1
SECCHI (METERS)	0.7 - 0.9	0.8	0.8	1.1 - 1.4	1.3	1.3	0.4 - 0.4	0.4	0.4

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR WOODRUFF NARROWS RESERVO
STORET CODE 5613

4TH SAMPLING (10/16/75)

PARAMETER	RANGE (2 SITES)	MEAN	MEDIAN
TEMP (C)	8.8 - 10.1	9.4	9.3
DISS OXY (MG/L)	6.8 - 7.8	7.5	7.6
CNDCTVY (MCROMO)	219. - 229.	225.	225.
PH (STAND UNITS)	8.4 - 8.5	8.5	8.5
TOT ALK (MG/L)	142. - 153.	147.	147.
TOT P (MG/L)	0.058 - 0.088	0.071	0.068
ORTHO P (MG/L)	0.019 - 0.034	0.022	0.021
NO2+NO3 (MG/L)	0.050 - 0.060	0.051	0.050
AMMONIA (MG/L)	0.060 - 0.080	0.070	0.070
KJEL N (MG/L)	0.500 - 0.800	0.612	0.600
INORG N (MG/L)	0.110 - 0.140	0.121	0.120
TOTAL N (MG/L)	0.550 - 0.850	0.664	0.650
CHLRPYL A (UG/L)	10.5 - 12.1	11.3	11.3
SECCHI (METERS)	0.4 - 0.9	0.6	0.6

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/16/75	1. Flagellates	7,723
	2. Chroomonas (?) sp.	1,296
	3. Centric diatoms	810
	4. Cryptomonas sp.	216
	5. Surirella sp.	54
	Other genera	55
	Total	10,154
08/07/75	1. Merismopedia sp.	676
	2. Schroederia sp.	386
	3. Chroomonas (?) sp.	145
	4. Anabaena sp.	97
	5. Cryptomonas sp.	97
	Other genera	48
	Total	1,449
09/18/75	1. Anabaena sp.	1,144
	2. Stephanodiscus sp.	654
	3. Aphanizomenon sp.	327
	4. Melosira sp.	122
	Total	2,247
10/16/75	1. Aphanizomenon sp.	205
	2. Stephanodiscus sp.	164
	3. Cryptomonas sp.	82
	4. Chroomonas (?) sp.	41
	5. Schroederia sp.	41
	Total	533

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/16/75	1	6.1
	2	6.1
08/07/75	1	2.5
	2	4.0
09/18/75	1	35.6
	2	26.7
10/16/76	1	12.1
	2	10.5

C. Limiting Nutrient Study:

Because of significant changes in nutrients in the samples from the time of collection to the beginning of the assays, the results are not considered representative of conditions in the reservoir at the times the samples were taken (09/18/75 and 10/16/75).

The reservoir data indicate nitrogen limitation at all four sampling times. The mean inorganic nitrogen to orthophosphorus ratios were 3 to 1 in May, 7 to 1 in August, 5 to 1 in September, and 6 to 1 in October; and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Wyoming National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v). Sampling was begun in October, 1974, and was completed in April, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Wyoming District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station A-2, in $kg/km^2/year$, and multiplying by the ZZ area in km^2.

The operator of the Evanston wastewater treatment plant provided monthly effluent samples and corresponding flow data.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Evanston	4,500	activated sludge	4019.3	Bear River

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Bear River	34,480	80.8
b. Minor tributaries & immediate drainage (non-point load) -	1,365	3.2
c. Known municipal STP's -		
Evanston	6,685	15.7
d. Septic tanks - None	-	-
e. Known industrial - None	-	-
f. Direct precipitation** -	125	0.3
Total	42,655	100.0

2. Outputs -

Lake outlet - 17,420

3. Net annual P accumulation - 25,235 kg.

* Prior, 1974.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Bear River	479,605	91.6
b. Minor tributaries & immediate drainage (non-point load) -	18,645	3.6
c. Known municipal STP's -		
Evanston	17,260	3.3
d. Septic tanks - None	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	7,645	1.5
Total	523,155	100.0

2. Outputs -

Lake outlet - 215,255

3. Net annual N accumulation - 307,900 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Bear River	18	246

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Whitney Canyon Creek	0.157	1.810
Red Canyon Creek	0.230	1.441

* See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	6.02	3.56	73.9	43.5

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Woodruff Narrows Reservoir:

"Dangerous" (eutrophic loading)	1.08
"Permissible" (oligotrophic loading)	0.54

V. LITERATURE REVIEWED

Prior, Roy E., 1974. Personal communication (reservoir morphometry; point sources). WY Dept. of Env. Qual., Cheyenne.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
5601	BIG SANDY RESERVOIR	0.087	0.060	487.667	4.383	8.800	0.020
5602	BOULDER LAKE	0.008	0.040	361.800	2.483	8.400	0.002
5603	BOYSEN RESERVOIR	0.037	0.140	465.923	6.264	14.400	0.014
5604	LAKE DE SMET	0.033	0.040	409.000	11.167	9.400	0.006
5605	FLAMING GORGE RESERVOIR	0.014	0.605	366.461	5.611	12.200	0.003
5606	FREMONT LAKE	0.006	0.040	-22.000	3.783	7.400	0.002
5607	GLENDO RESERVOIR	0.045	0.315	459.182	8.473	12.600	0.014
5608	KEY HOLE RESERVOIR	0.028	0.050	454.583	7.792	14.000	0.004
5609	OCEAN LAKE	0.043	0.040	478.333	7.500	8.600	0.004
5610	SEMINOLE RESERVOIR	0.030	0.130	447.000	2.536	11.000	0.007
5611	SODA LAKE	0.063	0.040	387.500	5.575	15.000	0.014
5612	VIVA NAUGHTON RESERVOIR	0.065	0.120	430.000	25.067	13.200	0.024
5613	WOODRUFF NARROWS RESERVO	0.069	0.105	470.000	12.950	13.200	0.019
5614	YELLOWTAIL RESERVOIR	0.026	0.310	364.500	5.410	10.000	0.017

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
5601	BIG SANDY RESERVOIR	0 (0)	54 (7)	0 (0)	77 (10)	77 (10)	8 (1)	216
5602	BOULDER LAKE	92 (12)	92 (11)	92 (12)	100 (13)	92 (12)	92 (12)	560
5603	BOYSEN RESERVOIR	46 (6)	23 (3)	23 (3)	46 (6)	8 (1)	42 (5)	188
5604	LAKE DE SMET	54 (7)	73 (9)	62 (8)	15 (2)	69 (9)	62 (8)	335
5605	FLAMING GORGE RESERVOIR	85 (11)	0 (0)	77 (10)	54 (7)	46 (6)	85 (11)	347
5606	FREMONT LAKE	100 (13)	73 (9)	100 (13)	85 (11)	100 (13)	100 (13)	558
5607	GLENDO RESERVOIR	31 (4)	8 (1)	31 (4)	23 (3)	38 (5)	42 (5)	173
5608	KEY HOLE RESERVOIR	69 (9)	62 (8)	38 (5)	31 (4)	15 (2)	69 (9)	284
5609	OCEAN LAKE	38 (5)	92 (11)	8 (1)	38 (5)	85 (11)	77 (10)	338
5610	SEMINOLE RESERVOIR	62 (8)	31 (4)	46 (6)	92 (12)	54 (7)	54 (7)	339
5611	SODA LAKE	23 (3)	92 (11)	69 (9)	62 (8)	0 (0)	31 (4)	277
5612	VIVA NAUGHTON RESERVOIR	15 (2)	38 (5)	54 (7)	0 (0)	27 (3)	0 (0)	134
5613	WOODRUFF NARROWS RESERVO	8 (1)	46 (6)	15 (2)	8 (1)	27 (3)	15 (2)	119
5614	YELLOWTAIL RESERVOIR	77 (10)	15 (2)	85 (11)	69 (9)	62 (8)	23 (3)	331

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	5602	BOULDER LAKE	560
2	5606	FREMONT LAKE	558
3	5605	FLAMING GORGE RESERVOIR	347
4	5610	SEMINOLE RESERVOIR	339
5	5609	OCEAN LAKE	338
6	5604	LAKE DE SMET	335
7	5614	YELLOWTAIL RESERVOIR	331
8	5608	KEY HOLE RESERVOIR	284
9	5611	SODA LAKE	277
10	5601	BIG SANDY RESERVOIR	216
11	5603	BOYSEN RESERVOIR	188
12	5607	GLENDO RESERVOIR	173
13	5612	VIVA NAUGHTON RESERVOIR	134
14	5613	WOODRUFF NARROWS RESERVO	119

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR WYOMING 08/05/76

LAKE CODE 5613 WOODRUFF NARROWS RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 2030.6

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
5613A1	2030.6	1.30	1.50	3.48	10.11	22.77	27.81	7.67	2.80	1.47	1.13	1.08	1.25	6.87
5613A2	1947.7	2.21	2.89	4.56	11.04	23.87	26.65	5.07	1.19	1.25	1.78	1.93	2.27	7.06
561381	0.0	0.0	0.0	0.0	0.0	0.0	0.028	0.0	0.0	0.0	0.0	0.0	0.0	0.002
5613ZZ	82.9	0.0	0.0	0.0	0.0	0.028	0.028	0.028	0.0	0.0	0.0	0.0	0.0	0.007

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2030.6
SUM OF SUB-DRAINAGE AREAS = 2030.6

TOTAL FLOW IN = 84.81
TOTAL FLOW OUT = 82.37

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5613A1	10	74	0.510	5	0.481				
	11	74	0.595	21	0.623				
	12	74	0.623						
	1	75	0.651						
	2	75	0.680						
	3	75	0.736	3	0.708				
	4	75	4.644	30	6.824				
	5	75	17.726						
	6	75	37.916						
	7	75	25.853						
	8	75	2.095						
	9	75	3.794						
5613A2	10	74	0.595	5	0.368				
	11	74	1.161	21	0.736				
	12	74	1.699						
	1	75	1.756						
	2	75	1.642						
	3	75	2.379						
	4	75	5.012	30	5.805				
	5	75	18.859						
	6	75	38.398						
	7	75	24.636						
	8	75	1.926						
	9	75	1.161						

TRIBUTARY FLOW INFORMATION FOR WYOMING 08/05/76

LAKE CODE 5613 WOODRUFF NARROWS RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
561381	10	74	0.0						
	11	74	0.0						
	12	74	0.0						
	1	75	0.0						
	2	75	0.0						
	3	75	0.0						
	4	75	0.0						
	5	75	0.0						
	6	75	0.028						
	7	75	0.0						
	8	75	0.0						
	9	75	0.0						
5613ZZ	10	74	0.0						
	11	74	0.0						
	12	74	0.0						
	1	75	0.0						
	2	75	0.0						
	3	75	0.0						
	4	75	0.0						
	5	75	0.028						
	6	75	0.028						
	7	75	0.028						
	8	75	0.0						
	9	75	0.0						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/08/05

561301
41 30 12.0 111 01 03.0 3
WOODRUFF NARROWS RESERVOIR
56041 WYOMING

11EPALES 2111202
0034 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/16	15 05	0000	10.7	8.6	34	362	8.55	264	0.030	0.700	0.070	0.022
	15 05	0005	10.6	9.0			8.55	286	0.020	0.600	0.020K	0.017
	15 05	0015	10.1	9.0		356	8.55	302	0.020K	0.600	0.020K	0.007
	15 05	0030	9.8	8.2		354	8.60	306	0.020	0.600	0.020K	0.019
75/08/07	14 45	0000	20.2	6.8	54	217	8.80	114	0.060	0.600	0.030	0.015
	14 45	0005	20.2	6.6		213	8.80	114	0.170	0.700	0.020K	0.017
	14 45	0015	20.1	6.6		211	8.80	114	0.320	0.700	0.020K	0.019
	14 45	0029	16.8	1.8		197	8.25	116	0.100	0.300	0.060	0.086
75/09/18	14 10	0000	13.4	9.8	15	243		139		0.700	0.020K	0.011
	14 10	0005	13.3	9.8		244	9.00	139		0.600	0.020K	0.007
	14 10	0015	12.6	8.6		242	8.90	142	0.020K	0.400	0.020K	0.007
	14 10	0031	12.3	8.2		240	8.00	134	0.020K	0.400	0.020K	0.007
75/10/16	11 45	0000	10.1	7.6	36	228	8.40	145	0.080	0.800	0.050	0.025
	11 45	0005	10.1	7.6		219	8.50	149	0.070	0.700	0.050	0.021
	11 45	0015	9.8	7.4		229	8.50	151	0.070	0.500	0.050	0.019
	11 45	0026	9.6	6.8		229	8.50	153	0.080	0.500	0.060	0.021

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/16	15 05	0000	0.098	6.1	
	15 05	0005	0.069		
	15 05	0015	0.067		
	15 05	0030	0.078		
75/08/07	14 45	0000	0.039	2.5	
	14 45	0005	0.038		
	14 45	0015	0.039		
	14 45	0029	0.166		
75/09/18	14 10	0000	0.092	35.6	
	14 10	0005	0.084		
	14 10	0015	0.079		
	14 10	0031	0.071		
75/10/16	11 45	0000	0.085	12.1	
	11 45	0005	0.070		
	11 45	0015	0.061		
	11 45	0026	0.080		

K VALUE KNOWN TO BE
LESS THAN INDICATED

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STORET RETRIEVAL DATE 76/08/05

561302
41 28 50.0 111 00 53.0 3
WOODRUFF NARROWS RESERVOIR
56041 WYOMING

150791

11EPALES 2111202
0024 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/16	15 25	0000	8.7	9.2	26	344	8.55	272	0.020	0.600	0.020K	0.016
	15 25	0005	8.5	9.0		341	8.50	280	0.030	0.500	0.020K	0.024
	15 25	0015	8.7	8.6		341	8.50	294	0.020	0.400	0.020K	0.007
	15 25	0020	7.1	8.0		331	8.55	278	0.030	0.500	0.020	0.008
75/08/07	15 15	0000	19.7	6.2	45	212	8.70	114	0.200	0.300	0.020K	0.027
	15 15	0005	19.7	6.2		212	8.70	112	0.260	0.300	0.020K	0.025
	15 15	0015	19.6	6.0		210	8.70	114	0.180	0.300	0.020K	0.026
	15 15	0024	19.6	6.2		215	8.70	115	0.140	0.300	0.020K	0.025
75/09/18	14 30	0000	13.0	9.0	15	251	9.00	136	0.020K	0.700	0.020K	0.008
	14 30	0005	13.0	8.4		251	8.95	140	0.020K	0.500	0.020K	0.008
	14 30	0015	12.7	8.2		252	8.90	140	0.020K	0.500	0.020K	0.007
	14 30	0024	12.4	8.6		243	8.95	137	0.020K	0.600	0.020K	0.011
75/10/16	11 20	0000	9.1	7.8	15	224	8.50	142	0.060	0.600	0.050	0.034
	11 20	0005	9.1	7.2		224	8.50	145	0.070	0.600	0.050	0.021
	11 20	0015	9.0	7.8		225	8.50	147	0.060	0.600	0.050	0.020
	11 20	0020	8.8	7.6		220	8.50	147	0.070	0.600	0.050	0.019

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/16	15 25	0000	0.063	6.1	
	15 25	0005	0.068		
	15 25	0015	0.065		
	15 25	0020	0.078		
75/08/07	15 15	0000	0.054	4.0	
	15 15	0005	0.051		
	15 15	0015	0.053		
	15 15	0024	0.048		
75/09/18	14 30	0000	0.087	26.7	
	14 30	0005	0.084		
	14 30	0015	0.073		
	14 30	0024	0.082		
75/10/16	11 20	0000	0.060	10.5	
	11 20	0005	0.088		
	11 20	0015	0.058		
	11 20	0020	0.066		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/08/05

561341
41 30 17.0 111 01 00.0 4
BEAR RIVER
56 7.5 WOODRUFF NAR
O/WOODRUFF NARROWS RES
BELOW WOODRUFF NARROWS DAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/05	11 50		0.200	1.300	0.220	0.070	0.140
74/11/21	11 00		0.136	1.100	0.125	0.030	0.050
75/04/30	12 30		0.015	1.050	0.030	0.020	0.080

STORET RETRIEVAL DATE 76/08/05

5613A2
41 26 05.0 111 00 50.0 4
BEAR RIVER
56 7.5 NE NEPST RES
T/WOODRUFF NARROWS RES 150791
BNK 30 FT FRM DRT RD 13.5 M N OF EVNSTON
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/05	09 50		0.032	0.800	0.025	0.005	0.025
74/11/21	09 25		0.008	1.600	0.040	0.020	0.030
75/03/03			0.200	2.525	0.435	0.115	0.325
75/04/30	13 00		0.005	1.750	0.120	0.030	0.110

STORET RETRIEVAL DATE 76/08/05

5613C1
41 26 42.0 111 00 14.0 4
WHITNEY CANYON CREEL
56 7.5 NE NEPST RES
T/WOODRUFF NARROWS RES 150791
DIRT RD BRDG 13.5 MI N OF EVANSTON
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/05	10 07		0.016	1.600	0.050	0.015	0.135
75/04/30	14 00		0.005	2.000	0.230	0.020	0.180

STORET RETRIEVAL DATE 76/08/05

561301
41 20 10.0 110 59 20.0 4
RED CANYON CREEK
56 7.5 EVANSTON
T/WOODRUFF NARROWS RES 110692
BANK OFF DIRT RD .7 MI E JCT W ST HWY 89
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/05	09 00		0.016	1.100	0.035	0.005K	0.010
74/11/21	08 50		0.008	1.000	0.035	0.010	0.010
75/03/03			0.185	2.500	0.115	0.440	0.800
75/04/30	12 55		0.005	0.950	0.020	0.025	0.100

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/05

5613AA AS5613AA P004500
41 17 00.0 110 58 00.0 4
EVANSTON
56 7.5 EVANSTON
T/WOODRUFF NARROWS RES. 110692
BEAVER RIVER
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/02/05	08	15	0.080	4.300	1.280	2.600	3.300	0.400	1.300
75/03/04	08	00	0.320	13.500	0.080K	1.700	5.550	2.000	2.000
75/04/04	08	00	0.100	19.000	0.220	1.920	6.500		
75/04/28	08	00	0.100	16.500	0.490	2.300	5.200		
75/06/08	08	00	0.300	21.000	0.290	2.500	4.500		
75/06/18	07	00	0.150	11.000	0.064	2.600	3.100		
75/08/25	07	30	0.025	14.500	0.860	2.400	5.500		
75/09/15	07	30	1.500	9.700	0.600	2.630	3.500	0.864	0.864
75/10/08	07	00	0.850	9.900	0.050	3.000	3.950	0.720	0.650
75/11/11			1.050	11.000	0.070	2.900	3.700	0.165	0.495

K VALUE KNOWN TO BE
LESS THAN INDICATED